

days west of the 180th meridian. In American coastal waters fog was noted on 10 days each off Washington and California; on 4 days off Oregon; and on 3 days off Lower California.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST

By BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Typhoon, August 28–September 5, 1940.—A low-pressure area far to the southeast of Guam moved west-northwest, rapidly developing to typhoon intensity as it proceeded. When the center reached the regions about 250 miles west of Guam, the direction changed to the northwest, and the storm continued along this course until it reached the latitude of southern Formosa. It shifted its movement to the west for 1 day (September 4) and disappeared east or east-southeast of Ishigakijima after a short inclination to the northwest.

Typhoon, September 2–12, 1940.—A low-pressure area appeared far to the east-northeast of Guam, moved west-northwest and became a typhoon, September 2, located about 300 miles north-northeast of Guam. It continued moving west-northwest, gradually inclining to the north-northwest, and passed about 90 miles southwest of the Bonins during the early morning hours of September 7, after shifting to the west-northwest. A change to the north occurred which brought the storm center to the ocean regions between the Bonins and Japan, September 9. It seemed to be stationary during the day, due to a high-pressure area over northern Japan and the Pacific Ocean. September 10, however, showed the center moving west-southwest, and it is thought that instead of being stationary on the preceding day, the center may have made a loop before moving toward the west-southwest. Over the ocean regions south of Japan, the typhoon changed to the northwest, a course which brought it to Kiu-siu Island. September 11, the storm recurved to the northeast over this island and on the following day it had weakened, apparently to a low pressure area which moved northeast across Japan.

The afternoon observation, September 6, from the Bonins, was the lowest in the series reported from that island during this storm. Pressure was 723.0 mm. (963.9 mb.) with north-northeast winds of force 12. From latitude 29° N., longitude 134° E., on the morning of September 10, a ship, name unknown, reported west winds, force 11, with pressure at 729.0 mm. (971.9 mb.).

While this storm was in progress, an observation was received from a ship, name unknown, in latitude 17°54' N., longitude 158°48' E., with west winds of force 8 and pressure at 996.2 mb. (September 7). This indicated the existence of a typhoon far to the east-northeast of Guam, but no other evidence was received either from that ship or other ships, to show its origin and progress. It is possible that there may have been a communication error and that the position given was wrong, but there is no way to check this at present.

Typhoon, September 6–7, 1940.—This typhoon must be considered in connection with the typhoon of August 28 to September 5, for it is possible that it might be the same disturbance. Until further evidence is received, it will be treated as a separate typhoon, which was central about 600 miles east of southern Formosa, September 6, and which then curved northwest, north, and northeast for 1 day, after which it weakened to a depression and then disappeared. No trace of the storm could be found on September 8. The observations which made this storm

appear to be independent of the typhoon of August 28–September 5, are the following: The S. S. *Steel Exporter* reported 0700 G. C. T. September 6, from latitude 20°18' N., longitude 129°30' E., a pressure of 744.8 mm. (993.0 mb.) with west-northwest winds of force 9. Also, the morning observation, September 6, from Rasa Jima Island (one of the Nansei Island group) was 747.8 mm. (997.0 mb.) for pressure and east-northeast, force 4, for winds.

Typhoon, September 11–19, 1940.—A depression, moving westerly, passed about 200 miles south of Guam and quickly inclined to the north, intensifying to typhoon strength, September 11 to 13. It was stationary, September 13 and 14, about 150 miles west-northwest of Guam, and then began a northwesterly and northerly course to the ocean regions about 300 miles west of the Bonins, where it recurved to the north-northeast and moved very rapidly toward the northern Pacific Ocean. The morning observation received from Hatidyojima Island, September 18, was 737.3 mm. (983.0 mb.) with north-northeast winds, force 7, which shows better than any other available observation what intensity the storm had reached.

Typhoon, September 22–October 2, 1940.—This storm first appeared far to the south-southeast of Guam and seemed to be a fully developed typhoon, September 22. It moved along a course in general west-northwest, but varying to the northwest and west for short periods. It finally reached the eastern part of the Balintang Channel, September 29, and passed close to and north of Basco late in the afternoon of that day. It inclined to the northwest apparently, and moved close to and west of Formosa Island toward China. It is believed that the center did not cross any portion of Formosa but observations are needed to be certain. After crossing Formosa Channel the center entered the continent within 100 miles northeast of Amoy, inclining to the north. Over land, the storm weakened and recurved to the northeast and entered the Eastern Sea about 150 miles south of Shanghai as a mild depression which quickly disappeared.

The only part of the Philippine Archipelago affected by this typhoon was the Batan Islands. Basco, the location of the Weather Bureau station, reported a minimum pressure of 723.61 mm. (964.7 mb.) with northwest winds of force 12, September 29, at 6:45 p. m. No loss of life and no serious damage was reported.

Only during this typhoon was there any strength in the upper winds over the Philippines, and the velocities did not increase to values above 50 k. p. h. until September 28 and 29. First increasing at Cebu and Zamboanga from the southwest quadrant, then a day later at Manila, Dagupan, and Aparri, as the directions changed from the northwest and north quadrants to the southwest, it seemed that the southwest air stream was drawn toward the typhoon center. This activity did not extend south or southwest of Zamboanga, according to available data, for there was no increase in the velocities of the southwest monsoon over Bandon, Thailand, and Saigon, Indo-China. Compared with other typhoons, for example, those of July 2–9 and July 6–16, 1940, whose centers moved along courses similar to that of September 22–October 2, there was a very great difference in the activity of the southwest monsoon.

During the July typhoons Cebu and Manila had velocities up to and over 100 k. p. h. and stations over southern Indo-China and Thailand were almost always reporting velocities over 50 k. p. h., often reaching 80 and 90 k. p. h. This typhoon situation had characteristics much different than that during the last few days of

September, when the southwest monsoon was not so active. In fact, it should be noted that the southwest monsoon current over the Philippine Islands, China Sea, and regions west and southwest, was quiet throughout the month of September, hardly ever reaching velocities of 50 k. p. h. and then only when a typhoon was exerting its influence. Bandon, Thailand, was reporting ascents almost every day until September 10, with velocities approximately 50 k. p. h., but the latter part of the month showed the southwesterly current much weaker. Regarding Guam, the velocities were almost always below 50 k. p. h., the exceptions being: (1) September 5 and 6, when the typhoon of September 2-12 was located north of Guam (southwest, west-southwest, west directions; 38-70 k. p. h. velocities); (2) September 15, when the typhoon of September 11-19 was central northwest of Guam (south to south-southwest directions; 44-67 k. p. h. velocities); and (3) September 24 and 25, when the typhoon of September 22-October 2 was west-northwest and north-west of Guam (southeast, south-southeast, and south directions; 29-67 k. p. h. velocities). U. S. Navy vessels at Tsingtao and Shanghai, China, frequently reported ascents that showed north, northeast, and east quadrant winds, with velocities between 20 and 60 k. p. h., sometimes due to typhoons, often not. This concludes the brief summary of September upper winds over the Far East.

RIVER STAGES AND FLOODS

By BENNETT SWENSON

Precipitation during September 1940 was deficient and river stages were generally low over the country east of the Rocky Mountains, except in New England and in portions of New Jersey, Oklahoma, and Kansas. In the area from the Rocky Mountains and Montana westward, except in California, the rainfall was decidedly above normal. Floods during the month were confined principally to small streams in New Jersey and the Arkansas River and tributaries in northeastern Oklahoma.

Atlantic Slope Drainage.—Heavy rains occurred on September 1 in southwestern New Jersey during the northward passage of a tropical disturbance with its center about 150 miles off the New Jersey coast. The greatest 24-hour amounts (within 12 hours at most stations) reported were: Clayton, 10.52; Pemberton, 6.70; Woodbury, 6.50; Woodstown, 5.40; North Merchantville, 5.19; Burlington, 4.86; Moorestown, 4.50, and Trenton No. 2, 4.91 inches. Severe flooding occurred in a number of the smaller rivers, and several dams broke, resulting in the loss of four lives and property damage (mostly to highways and bridges) estimated at more than \$1,000,000.

Stages were slightly above flood stage at some points in the James, Santee, and Savannah Rivers early in September, being largely a continuation of the August flood conditions.

Arkansas Basin.—Unusually heavy rainfall occurred on September 3-4 over a small area in northeastern Oklahoma in the vicinity of the junction of the Cimarron and Arkansas Rivers. Rainfall amounts of 8 inches or more were recorded in a narrow band approximately 30 miles wide and 100 miles long, paralleling and lying just to the south and west of the Arkansas River from immediately south of Tulsa, Oklahoma, northwestward almost

to the Kansas border. The area of greatest precipitation, 18 inches or more, was located in the triangle formed by the junction of the Cimarron and the Arkansas Rivers. The greatest single amount recorded in this area was 19.75 inches at Hallett, Okla.

The observed precipitation for the storm is given in table 1. These data were obtained through the cooperative hydrologic program conducted by the Weather Bureau in cooperation with the Departments of War and Agriculture.

Hourly rainfall amounts obtained from the Weather Bureau airport station recording-gage at Tulsa Airport are given in table 2. Additional precipitation reports by Weather Bureau observers in Oklahoma and in southeastern Kansas may be found in Climatological Data for September, issued by the section centers of the respective States.

The meteorological conditions which gave rise to the unusual precipitation are not clearly discernable on the surface weather map. However, the isentropic chart, from upper-air soundings, gives an explanation of the causes.

On the morning of September 3 a large, cold cyclonic eddy appeared on the 314° potential-temperature surface with center over Oregon. In advance of this eddy a moist tongue of air was advancing northward over extreme eastern Mexico, extending northward to extreme eastern Montana. The flow pattern gives some indication of a separate anticyclonic eddy branching eastward over Kansas.

On the same potential-temperature surface for the morning of September 4 the southern anticyclonic branch was well established, indicating a moist tongue curving sharply anticyclonically and moving up-slope toward the southeast over southeastern Kansas and northeastern Oklahoma. The stream functions showed this southern eddy to be centered over Texas. Another anticyclonic eddy composed mostly of dry air was central over southern Minnesota. Convergence between these two eddies and the upslope component in the moist eddy brought about the realization of the latent energy in the southern moist tongue. According to the flow pattern, Oklahoma City was not in the center of the moist tongue on either day, but, nevertheless, on both days the Oklahoma City upper-air soundings showed a lapse rate which indicated marked conditional instability. The Oklahoma soundings further indicated that the quantities of available precipitable water were quite high.

The flooding was severe along the Arkansas and Cimarron Rivers in the vicinity of Tulsa, Bristow, and Cleveland. The soil was dry and the stages in the streams were quite low at the beginning of the storm. These conditions tended to reduce runoff and alleviate flood conditions somewhat.

The Arkansas River at Tulsa rose from a stage of 1.8 feet at 8 a. m., to 16.0 feet at 7 p. m., of the 4th. The crest stage reached at that place was 19.3 feet on the morning of the 5th, 3.3 feet above flood stage and just 0.5 foot below the highest stage of record in June 1923. The losses in and around Tulsa have been estimated at more than a million dollars. At Fort Smith, Ark., the river rose to a stage of 19.8 feet on September 7, but no damage was reported.